CLAIMS

1. A method for calibrating downlink and uplink channels in a wireless communication system, comprising:

obtaining an estimate of a downlink channel response;

obtaining an estimate of an uplink channel response;

determining first and second sets of correction factors based on the estimates of the downlink and uplink channel responses; and

calibrating the downlink channel and uplink channel based on the first and second sets of correction factors, respectively, to form a calibrated downlink channel and a calibrated uplink channel.

2. The method of claim 1, wherein the first set of correction factors is used to scale symbols prior to transmission on the downlink channel and the second set of correction factors is used to scale symbols prior to transmission on the uplink channel.

3. The method of claim 1, wherein the first set of correction factors is used to scale symbols received on the downlink channel and the second set of correction factors is used to scale symbols received on the uplink channel.

4. The method of claim 1, wherein the first and second sets of correction factors are determined based on the following equation:

$$\underline{\hat{\mathbf{H}}}_{\mathrm{up}}\underline{\hat{\mathbf{K}}}_{\mathrm{ut}} = (\underline{\hat{\mathbf{H}}}_{\mathrm{dn}}\underline{\hat{\mathbf{K}}}_{\mathrm{ap}})^T ,$$

where $\underline{\hat{\mathbf{H}}}_{\mathrm{dn}}$ is a matrix for the estimate of the downlink channel response,

$\underline{\hat{\mathbf{H}}}_{\mathrm{up}}$ is a matrix for the estimate of the uplink channel response,

$\underline{\hat{\mathbf{K}}}_{\mathrm{ap}}$ is a matrix for the first set of correction factors,

$\underline{\hat{\mathbf{K}}}_{\mathrm{ut}}$ is a matrix for the second set of correction factors, and

" T " denotes a transpose.

5. The method of claim 4, wherein determining the first and second sets of correction factors includes:

computing a matrix $\underline{\mathbf{C}}$ as an element-wise ratio of the matrix $\hat{\underline{\mathbf{H}}}_{\text{up}}$ over the matrix $\hat{\underline{\mathbf{H}}}_{\text{dn}}$, and

deriving the matrices $\hat{\underline{\mathbf{K}}}_{\text{ap}}$ and $\hat{\underline{\mathbf{K}}}_{\text{ut}}$ based on the matrix $\underline{\mathbf{C}}$.

6. The method of claim 5, wherein the deriving the matrix $\hat{\underline{\mathbf{K}}}_{\text{ut}}$ includes

normalizing each of a plurality of rows of the matrix $\underline{\mathbf{C}}$, and

determining a mean of the plurality of normalized rows of the matrix $\underline{\mathbf{C}}$, and wherein the matrix $\hat{\underline{\mathbf{K}}}_{\text{ut}}$ is formed based on the mean of the plurality of normalized rows.

7. The method of claim 5, wherein the deriving the matrix $\hat{\underline{\mathbf{K}}}_{\text{ap}}$ includes

normalizing each of a plurality of columns of the matrix $\underline{\mathbf{C}}$, and

determining a mean of inverses of the plurality of normalized columns of the matrix $\underline{\mathbf{C}}$, and wherein the matrix $\hat{\underline{\mathbf{K}}}_{\text{ap}}$ is formed based on the mean of the inverses of the plurality of normalized columns.

8. The method of claim 4, wherein the matrices $\hat{\underline{\mathbf{K}}}_{\text{ut}}$ and $\hat{\underline{\mathbf{K}}}_{\text{ap}}$ are derived based on a minimum mean square error (MMSE) computation.

9. The method of claim 8, wherein the MMSE computation minimizes a mean square error (MSE) given as

$$|\hat{\underline{\mathbf{H}}}_{\text{up}}\hat{\underline{\mathbf{K}}}_{\text{ut}} - (\hat{\underline{\mathbf{H}}}_{\text{dn}}\hat{\underline{\mathbf{K}}}_{\text{ap}})^T|^2 .$$

10. The method of claim 1, further comprising:

determining a scaling value indicative of an average difference between the estimate of the downlink channel response and the estimate of the uplink channel response.

11. The method of claim 1, wherein the estimates for the downlink and uplink channel responses are normalized to account for receiver noise floor.

12. The method of claim 1, wherein the determining is performed at a user terminal.

13. The method of claim 4, wherein a first set of matrices of correction factors for the downlink channel is determined for a first set of subbands, the method further comprising:

interpolating the first set of matrices to obtain a second set of matrices of correction factors for the downlink channel for a second set of subbands.

14. The method of claim 1, wherein the estimates of the downlink and uplink channel responses are each obtained based on a pilot transmitted from a plurality of antennas and orthogonalized with a plurality of orthogonal sequences.

15. The method of claim 1 wherein the estimate of the uplink channel response is obtained based on a pilot transmitted on the uplink channel and wherein the estimate of the downlink channel response is obtained based on a pilot transmitted on the downlink channel.

16. The method of claim 1, wherein the TDD system is a multiple-input multiple-output (MIMO) system.

17. The method of claim 1, wherein the TDD system utilizes orthogonal frequency division multiplexing (OFDM).

18. A method for calibrating downlink and uplink channels in a wireless time division duplexed (TDD) multiple-input multiple-output (MIMO) communication system, comprising:

transmitting a pilot on the uplink channel;

obtaining an estimate of an uplink channel response derived based on the pilot transmitted on the uplink channel;

receiving a pilot on the downlink channel;

obtaining an estimate of a downlink channel response derived based on the pilot received on the downlink channel; and

determining first and second sets of correction factors based on the estimates of the downlink and uplink channel responses, wherein a calibrated downlink channel is formed by using the first set of correction factors for the downlink channel and a calibrated uplink channel is formed by using the second set of correction factors for the uplink channel.

19. The method of claim 18, wherein the first and second sets of correction factors are determined based on a minimum mean square error (MMSE) computation.

20. The method of claim 18, wherein the first and second sets of correction factors are determined based on a matrix-ratio computation.

21. The method of claim 18, wherein the first set of correction factors is updated based on calibration with a plurality of user terminals.

22. The method of claim 18, further comprising:

scaling symbols with the first set of correction factors prior to transmission on the downlink.

23. The method of claim 18, further comprising:

scaling symbols with the second set of correction factors prior to transmission on the uplink channel.

24. An apparatus in a wireless time division duplexed (TDD) multiple-input multiple-output (MIMO) communication system, comprising:

means for obtaining an estimate of a response of a downlink channel;

means for obtaining an estimate of a response of an uplink channel; and

means for determining first and second sets of correction factors based on the estimates of the downlink and uplink channel responses, wherein a calibrated downlink channel is formed by using the first set of correction factors for the downlink channel

and a calibrated uplink channel is formed by using the second set of correction factors for the uplink channel.

25. A user terminal in a wireless time division duplexed (TDD) communication system, comprising:

an TX spatial processor operative to transmit a first pilot on an uplink channel;

an RX spatial processor operative to receive a second pilot on a downlink channel and derive an estimate of a downlink channel response based on the received second pilot, and to receive an estimate of an uplink channel response derived based on the transmitted first pilot; and

a controller operative to determine first and second sets of correction factors based on the estimates of the downlink and uplink channel responses, wherein a calibrated downlink channel is formed by using the first set of correction factors for the downlink channel and a calibrated uplink channel is formed by using the second set of correction factors for the uplink channel

26. The user terminal of claim 25, wherein the controller is further operative to determine the first and second sets of correction factor based on a minimum mean square error (MMSE) computation.

27. The user terminal of claim 25, wherein the controller is further operative to determine the first and second sets of correction factor based on a matrix-ratio computation.

28. A method for communication in a wireless system, comprising:

calibrating one or more communication links between a plurality of user stations and one or more access points, based on one or more sets of correction factors derived from estimates of channel responses associated with the one or more communication links, the plurality of user stations including a first user station and a second user station; and

establishing communication between the first and second user stations using steering without performing calibration between the first and second user stations.

29. The method of claim 28 wherein establishing the communication between the first and second user stations comprises:

sending, from the first user station, a pilot and a request to establish a communication link with the second user station;

sending, from the second user station, a steered pilot and an acknowledgment in response to receiving the pilot and the request from first user station;

transmitting information between the first and second user stations using steering based on the steered pilot.

30. The method of claim 29 wherein the request to establish the communication comprises an identifier of a basic service set to which the first user station belongs and an identifier of the first user station.

31. The method of claim 29 wherein the acknowledgment comprises an identifier of the second user station, an identifier of a basic service set to which the second user station belongs, and a data rate indicator.

32. The method of claim 28 wherein the one or more access points includes a first access point associated with a first basic service set (BSS) and a second access point associated with a second BSS, wherein the first user station is calibrated with respect to the first access point and the second user station is calibrated with respect to the second access point, and wherein establishing the communication between the first and second user stations comprises:

sending, from the first user station, a pilot and a request to establish a communication link with the second user station;

sending, from the second user station, a steered pilot and an acknowledgment in response to receiving the pilot and the request from first user station; and

transmitting information between the first and second user stations using steering that is adjusted to compensate for a phase rotation caused by calibration of the first and second user stations with respect to different access points.

33. The method of claim 32 wherein the phase rotation is determined based on the steered pilot received from the second user station.

34. An apparatus for communication in a wireless system, comprising:

means for alibrating one or more communication links between a plurality of user stations and one or more access points, based on one or more sets of correction factors derived from estimates of channel responses associated with the one or more communication links, the plurality of user stations including a first user station and a second user station; and

means for establishing communication between the first and second user stations using steering without performing calibration between the first and second user stations.

35. The apparatus of claim 34 wherein establishing the communication between the first and second user stations comprises:

means for sending, from the first user station, a pilot and a request to establish a communication link with the second user station;

means for sending, from the second user station, a steered pilot and an acknowledgment in response to receiving the pilot and the request from first user station;

means for transmitting information between the first and second user stations using steering based on the steered pilot.

36. The apparatus of claim 35 wherein the request to establish the communication comprises an identifier of a basic service set to which the first user station belongs and an identifier of the first user station.

37. The apparatus of claim 35 wherein the acknowledgment comprises an identifier of the second user station, an identifier of a basic service set to which the second user station belongs, and a data rate indicator.

38. The apparatus of claim 34 wherein the one or more access points includes a first access point associated with a first basic service set (BSS) and a second access point associated with a second BSS, wherein the first user station is calibrated with respect to the first access point and the second user station is calibrated with

respect to the second access point, and wherein establishing the communication between the first and second user stations comprises:

sending, from the first user station, a pilot and a request to establish a communication link with the second user station;

sending, from the second user station, a steered pilot and an acknowledgment in response to receiving the pilot and the request from first user station; and

transmitting information between the first and second user stations using steering that is adjusted to compensate for a phase rotation caused by calibration of the first and second user stations with respect to different access points.

39. The apparatus of claim 38 wherein the phase rotation is determined based on the steered pilot received from the second user station.